PLANNING CONCEPTS AND OBJECTIVES

THE GOALS

The objective of water resources planning is to provide a comprehensive State water plan that will serve as a flexible guide to State policy for the development, management, conservation, and protection of water resources for the State. The plan will identify and equitably consider the public and private interests and institutions of the entire State, giving appropriate attention to environmental factors, while promoting economic welfare. The plan, as a flexible guide, will identify alternative strategies for implementation in order to give direction to appropriate private and public institutions in the State to enable them to:

1. Supply in a cost-effective manner sufficient quantities of suitable quality water in each area of the State, as the population and the economy of Texas grow, taking into account the potentially achievable effects of improved water-use efficiency and water conservation;

2. Continuously protect the quality of both surface and ground water in each area of the State, and where practical and feasible, improve its quality; and,

3. Provide protection of human life and public and private property from flooding and flood damage, to the extent that such flood protection can be determined to be economically feasible.

A Texas Water Plan adopted by the Texas Water Development Board is a flexible guide for use by the State, local governments, and the private sector to solve their water problems.

The Texas Department of Water Resources, other State agencies, and federal agencies provide information and technical assistance to local governments and the private sector to solve certain local water-related problems, and can provide limited financial assistance to local governments for these purposes. The Department, other State agencies, and federal agencies also administer regulatory programs pertaining to water quality and water rights, but the State agencies normally do not engage in the construction and operation of water works facilities. Local governments and private establishments, assisted to some extent by federal agencies, must develop detailed water quality protection and water supply project plans, arrange for the necessary permits, obtain financing, and construct and operate water works facilities.

WATER RIGHTS

Formulation of the Texas Water Plan has been based upon these tenets of water rights administration:

1. The Plan will not interfere with vested rights under existing water right permits.

2. For planning purposes, intrabasin needs for all beneficial purposes developing within the ensuing 50-year period will have priority over exportation for out-of-basin demands.

3. Water temporarily surplus to intrabasin requirements and to the satisfaction of existing rights at any time will be conserved and exported to meet out-of-basin needs only under valid permit and contractual agreements.

4. Rights under any new permits as might be held by the Texas Water Development Board will be obtained through full compliance with rules and procedures of the Texas Department of Water Resources.

FEDERAL-STATE-LOCAL RELATIONSHIP

There are several federal agencies and departments with the authority and responsibility to assist states in the development, utilization, and conservation of water. The most notable of these are the U.S. Army Corps of Engineers, the U.S. Bureau of Reclamation, the U.S. Geological Survey, the U.S. Soil Conservation Service, and the U.S. Environmental Protection Agency. There are ten

State agencies in Texas that have responsibilities to a varying degree for the administration of water law and water policy. Of these, the Texas Department of Water Resources has the major responsibility for managing water resources. However, the political subdivisions at the regional and local levels of government, of which there are more than 2,100 in Texas, actually construct (except for federally constructed multi-purpose reservoirs), operate, and maintain the water supply and wastewater treatment facilities in Texas. In addition, there are about 800 rural water supply corporations, 750 investor-owned public water supply systems, and thousands of private water and wastewater systems operating in Texas.

Implementation of the Texas Water Plan will continue to be a coordinated and cooperative effort of the federal government, the State of Texas, political subdivisions of the State, and private interests, each acting within the scope of its authority and policies, and within the objectives and framework of the Plan. The State will be a major participant, on a partnership basis with the federal government, in assisting local interests with the orderly development of the State water resources. However, it is clear that the State will have to play a greater role in financial assistance in the future than it has in the past due to the trend toward declining federal participation.

INTERSTATE STREAM COMPACTS

The apportionment of water from sources flowing along or across the boundaries of Texas will be made on the basis of the five jointly conceived interstate stream compacts that have been ratified by the states involved and the U.S. Congress.

THE PLANNING HORIZON

The planning horizon for this amended water plan is the period 1980 through 2030, with all important data and projections of annual water requirements and annual water supplies tabulated and listed for the years 1980, 1990, 2000, 2010, 2020, and 2030, respectively. This specification of the 50-year planning horizon is necessary in order to comply with Section 16.052 of the Texas Water Code which provides that for the purpose of planning the basin of origin of any surplus surface waters shall have its projected 50-year water requirements protected from transfer out of the basin except on a temporary interim basis.

THE PLANNING AREAS

Texas has 15 river basins and 8 coastal basins. In accordance with Section 16.051 of the Texas Water Code, each basin is designated as a separate planning area for the purpose of calculating in-basin water supplies and for projecting the 50-year foreseeable future in-basin water requirements. Because of the wide range of hydrologic conditions and water uses within Texas river and coastal basins, each basin has been divided into homogeneous subareas or zones to facilitate presentation of information and planning analyses (Figure 4).

POPULATION AND ECONOMIC GROWTH

In preparing projections of future water requirements, it was assumed that an adequate supply of suitable quality water would not be a limiting factor influencing future population and associated economic growth in Texas. However, the projections are based on the availability of all other resources, including current industries, educational institutions, labor force, capital markets, business atmosphere, natural resources, and state, national, and world markets. Based on different sets of assumptions regarding these generalized resources, a range of scenarios with high and low limits were developed. The projection process thus results in a range of possible values at a given point in time. Because of the long lead times involved in developing a major surface-water supply project, over 20 years at the present time, and because the accuracy of predictions diminishes with time, projections should be revised periodically to reflect changing conditions. Projections should be revised at least every 10 years, and ideally every 5 years, if they are to be acceptable as a basis for planning.

GROUND-WATER AVAILABILITY

The estimate of the ground-water supply capability of each area of the State is based on the assumption that some form of ground-water management program will be instituted in each area of the State where it is prudent to do so. For some areas, it is feasible to allocate ground-water supplies on a safe-yield basis, specifically, in areas where natural recharge is significant and in some areas where ground water can be "mined" from storage without causing harm to the aquifer or to users. Using the safe-yield approach, it is assumed that ground-water supplies to be utilized in many cases in conjunction with surface-water supplies and facilities, particularly where such coordinated operation of water supply facilities would be expected to lower the cost of providing adequate water supplies.

In parts of West Texas and in the High Plains, where natural recharge to aquifers is negligible and ground-water mining is necessary and practical, it is assumed that ground water will be mined at a decreasing future annual rate according to the hydrologic capabilities of the aquifers. Where applicable and feasible, alteration in the areal distri-

bution of pumpage is taken into account in the planning projections. In these areas, significant water shortages are projected to occur, and in certain cases some surface-water supplies would be allocated to reduce the shortages, whenever such surface-water supplies can be feasibly considered as potential sources of water to offset the reduction in supplies of ground water.

SURFACE-WATER AVAILABILITY

Surface-water supplies estimated in the Plan to be available for use and distribution to meet total projected future water needs in the State are based upon quantities that are anticipated to be available during a recurrence of the most critical drought period of record. Supplies available in such drought periods represent the smallest volume of surface-water supplies anticipated to be available for beneficial use. The sources of these supplies include the firm annual yields of reservoirs, direct runoff and spring-flow during the worst year of the critical drought, and municipal and manufacturing return flows upstream of major reservoirs and water diversion points.

The water available from a particular reservoir project is based upon the firm annual yield of the project. The firm annual yield of a reservoir is defined as the maximum quantity of water that can be withdrawn each year, on a dependable basis, during a repetition of the most critical drought of record.

Projected annual return flows from municipal and manufacturing water users are included in water availability projections in the Plan. These return flows are included as a surface-water resource where they could reasonably be expected to be captured for reuse. Return flows from irrigation are estimated but are not considered as a dependable resource for planning future water supply because irrigation return flows of any significance occur only in coastal areas and generally cannot be captured for reuse. However, return flows not recaptured for reuse represent an important freshwater inflow source for Texas bays and estuaries.

PROJECT PRIORITIZATION

On the basis of projections of population and economic growth and associated water needs, water-resource projects considered necessary to meet these needs are specifically identified and described in *Volume 2—WATER FOR TEXAS: Technical Appendix*, in the discussion of problems and needs within each river and coastal basin of the State. These projects, which include well fields, additional or enlarged reservoirs, and new or enlarged water-delivery systems to convey raw water supplies from existing or new sources to areas of current or projected need, are scheduled according to their estimated time of need. In practice, each project will be staged and constructed by local and regional units of government in time to meet water demands as they develop. The merits of each project will be evaluated on a case-by-case basis by the local sponsors and, where appropriate, by the State, considering need, existing statutory water use priorities, and the ability to improve the efficiency of the future use of the water resource in the particular region or locale.

WATER USE CATEGORIES

The major water-using purposes for which future water demands were projected are: municipal and commercial; industrial; steam-electric power; agricultural; and mining. These purposes are defined below.

With the exception of some light manufacturing operations, the municipal and commercial water use category includes the quantity of water used by people in private residences for drinking, cooking, dishwashing, laundry, bathing, toilet flushing, lawn watering, car washing, swimming pools, and other purposes; by business establishments, restaurants, car washes, public offices and institutions (except municipally-owned steam-electric generating plants); and by municipalities for sanitation, maintenance of grounds, fire protection, swimming pools, and other users supplied from municipal systems. Light manufacturing water use is included in the municipal category, in contrast to the industrial use category, since the characteristics of water use—drinking, sanitation, air-conditioning—in these manufacturing firms more closely compare to the characteristics of municipal use than to the characteristics of industrial use.

Water used for industrial purposes is distinguished from water used for municipal and commercial purposes in that it is an integral part of the production process. In addition to drinking and sanitary water uses, industrial water requirements serve such process-specific purposes as cooling, boiler feed, cleaning and washing, pollution control, and extraction and separation of desirable materials from by-products and waste materials. Incorporation of water into the final product also is a major aspect of industrial water demand, especially in the production of food and beverage products.

Steam-electric power plants use large quantities of water to remove heat from their condensers, plus a small quantity of water for boiler feed make-up. Only a small fraction of the condenser cooling water, about, one percent, is actually consumed through evaporation, however, and the remainder is commonly returned to an adjacent cooling pond and subsequently recirculated through the

condensers. In some situations, the condenser cooling water is drawn from a moving body of water—river, reservoir—and thus makes only a single pass through the condensers. In these situations, only the quantity of water evaporated in dispelling the heat absorbed from the condenser is part of steam-electric power generation water requirements. Similarly, in systems using cooling ponds, only the quantity of water evaporated is considered in steam-electric power generation water requirements. With respect to steam-electric power plants which derive cooling and boiler-feed water needs from ground-water sources, the total volume of ground water withdrawn from storage is considered consumed.

Agricultural water use accounts for the water that is used on-farm for irrigation of field, vegetable, and orchard crops and for livestock watering. In irrigated areas supplied from surface-water sources, water losses incurred in transport from the supply source to the farm are also included as a part of the agricultural water requirements.

The principal use of fresh water for mining in Texas is in the recovery of crude petroleum by waterflooding oil-bearing formations. Lesser volumes are used in the production of sand and gravel, in the recovery of minerals other than petroleum to separate useful materials from by-products and waste, and for land reclamation following the surface mining of lignite.

PLANS TO MEET WATER QUALITY PROTECTION AND WATER SUPPLY NEEDS

In order to solve Texas water problems, it will be necessary to protect the quality of existing supplies, increase the efficiency with which water is used, increase the quantity of water supplies where additional supply can be developed, and provide flood protection where possible. Water conservation through increased water-use efficiency in agriculture and industry, reduced per capita use of municipal supplies, and reduction in distribution line leakage can allow existing supplies to meet the needs of a larger number of people and support larger levels of industry and agriculture. However, it is clear that water conservation alone cannot meet all of the growing needs for water. Thus, it will be necessary, where possible, to increase the use of ground water, develop additional surface water, continue the research and development of desalting, ground-water recovery, and weather modification technologies, and consider importing water from outside the State.

The amended Texas Water Plan, as formulated in this report, is an assessment of the future water needs of Texas and proposed actions to meet these needs, where practical. The proposed actions include conservation and reuse, construction of wastewater treatment plants, the development of both ground- and surface-water resources, the development of storage, distribution, and treatment facilities, research, and flood protection. A schedule of proposed facility construction is included in the Plan.

The proposed action program in this Plan is intended to be a flexible guide to the management and development of the State's water resources. The implementation of this plan depends to a large extent upon actions of local and regional interests, such as municipalities, river authorities, water districts, and private enterprises. The Department will be involved in water conservation, water quality protection, water rights administration, and water resources planning; however, the construction, operation, and maintenance of projects must be done by local and regional units of government, and the private sector.

PROJECTIONS—POPULATION AND WATER REQUIREMENTS

Texas population has increased rapidly since 1930 (Figure 7). In each decade growth has been above the national increase, and in the decade of the 1970's the increase was much greater than the national average, 27.1 percent for Texas and 11.1 percent for the Nation. By 1930, the population of the State had risen to 5.8 million, by 1960, to 9.6 million, and by 1980, to 14.2 million. In 1983, the Texas labor force is reported at 7.41 million, with 6.85 million employed. Annual personal income is nearly $175 billion. Texas has developed into a broad-based industrial, service, trades, energy, and agricultural economy. The people, the economy, and the environment must have dependable supplies of suitable quality water in order to survive and to continue to enjoy a favorable level of living.

Projections of population and future levels of manufacturing, energy, and agricultural production were made for counties, and cities as appropriate. High Series and Low Series projections were made for population growth and for each of these major water-use categories. Population projections are based on vital statistics for each Texas county, with different estimates of migration rates into Texas distinguishing the two series. The High Series reflects a continuation, on through the 1980's and the decade of the 1990's, of the high rate of migration into the State experienced during the 1970's. The Low Series reflects a slower rate of migration into the State characteristic of rates of the past three decades. Economic growth projections are based upon the best available data from industry and agriculture, including the outlook for foreign markets and foreign competition in manufacturing. From these population and economic projections, water quality protection and water supply needs in municipal, commercial, and rural-area domestic uses, and manufacturing, agriculture, steam-electric power generation, and mining needs were derived. Corresponding with the High and Low Series projections of population and economic activity, a High and Low Series of water requirements were projected.

In 1980, the reported population of the State was 14.2 million people (Table 1; Figure 7). The largest cities in the State are Houston, Dallas, San Antonio, El Paso, Fort Worth, Austin, Corpus Christi, Lubbock, Arlington, and Amarillo (Table 2). In the High Series population projection, the State population is projected to be 21.2 million in the year 2000, increasing to 34.3 million in 2030 (Table 1). In the Low Series population projection,

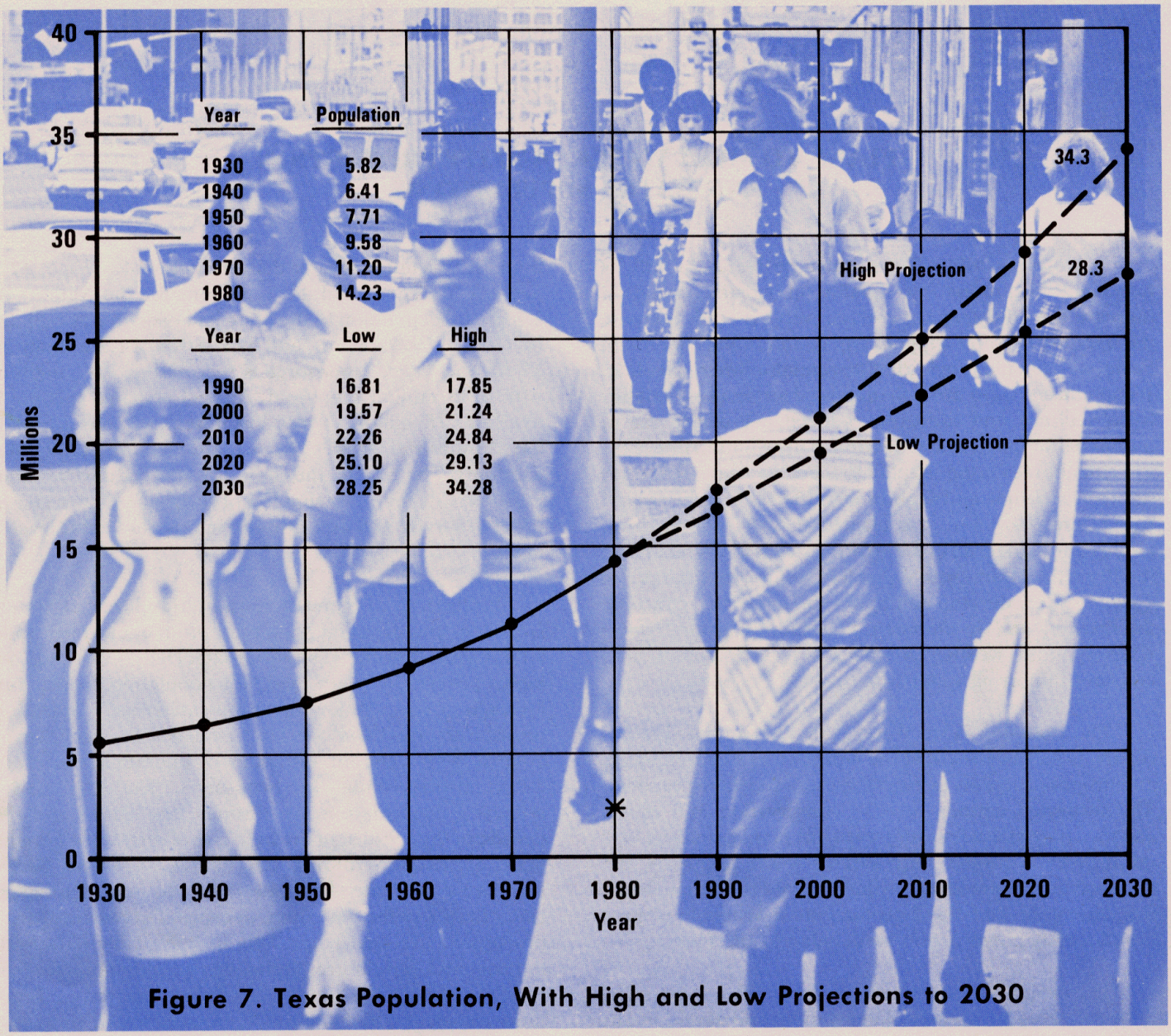

Figure 7. Texas Population, With High and Low Projections to 2030

the State population is projected to be 19.6 million in the year 2000, increasing to 28.3 million in 2030 (Table 1).

Of the total 17.9 million acre-feet of water used in the State in 1980, 15.8 percent was for municipal and domestic use , 8.5 percent was for industrial use, 1.8 percent was for steam-electric power use, 72.5 percent was for agricultural use, and 1.3 percent was used in mining operations.

Municipal and domestic uses in the State totaled 2.8 million acre-feet during 1980. Projections of future municipal and domestic water requirements are based upon population projections and projected per capita water use. Per capita water use estimates are based upon water use data reported by the suppliers of municipal and commercial water within each county, and upon statistical analyses of trends in per capita water use rates through time. Reported municipal and commercial water use shows an upward trend of four gallons per person per decade for the State. Estimates of these trends were made for each city and were applied in the projections through the year 2000. These analyses of per capita water use relate water use to local and regional climatic characteristics and to historical and projected economic factors for the State. Per capita water requirements projected for the High Series take into account the demands that will be placed upon water supply sources and treatment and distribution facilities during drought conditions. Per capita requirements for

Table 1

Reported and Estimated Population and Water Use in 1980 with Projections of Future Population and Annual Water Requirements for 2000 and 2030, Low and High Series, State of Texas

1980	Population[1]	14,227,571	
	Municipal and Domestic[2]	2,813,182	
	Manufacturing[2]	1,519,992	
	Mining[2]	239,076	
	Steam-Electric[2]	330,057	
	Agriculture (Irrigation and Livestock)[2]	12,950,357	
	TOTAL (Water)[3]	17,852,664	
		Low	**High**
2000	Population[1]	19,567,335	21,239,279
	Municipal and Domestic[2]	3,512,065	5,080,510
	Manufacturing[2]	2,407,092	2,717,673
	Mining[2]	267,671	267,671
	Steam-Electric[2]	717,440	816,940
	Agriculture (Irrigation and Livestock)[2]	10,426,908	16,542,538
	TOTAL (Water)[3]	17,331,176	25,425,332
2030	Population[1]	28,254,495	34,276,928
	Municipal and Domestic[2]	5,058,994	8,177,532
	Manufacturing[2]	4,230,531	5,013,989
	Mining[2]	387,128	387,128
	Steam-Electric[2]	1,118,619	1,417,449
	Agriculture (Irrigation and Livestock)[2]	11,385,468	15,350,638
	TOTAL (Water)[3]	22,180,740	30,346,736

[1]Population in number of persons.
[2]Water in acre-feet annually.
[3]In addition, estimated fresh water inflow requirements for Texas' bays and estuaries range from a low (survival limit) of 4.7 million acre-feet annually to a high (enhancement) of 13.6 million acre-feet annually.

the Low Series are for average weather and climate conditions. Per capita water use is not projected to increase after 2000, due primarily to the effects of conservation.

High Series municipal water requirements to meet needs during extended drought conditions are estimated to be 4.2 million acre-feet annually in 1990. For the year 2000, total State municipal water requirements are projected to be 5.1 million acre-feet annually, increasing to 8.2 million acre-feet annually by the year 2030 (Figure 8). Low Series municipal water requirements are projected to be 3.0 million acre-feet in 1990, 3.5 million acre-feet annually by the year 2000, and 5.1 million acre-feet annually by the year 2030.

Table 2

Reported and Estimated Population and Water Use in 1980 for the Largest Cities in Texas with Projections of Future City Population and Annual Municipal Water Requirements for 2000 and 2030, Low and High Series.

1980

City	Population (thousands)	Acre-Feet (thousands)
Houston	1,595.1	354.2
Dallas	904.1	227.7
San Antonio	785.9	183.2
El Paso	425.3	88.9
Fort Worth	385.1	91.8
Austin	345.5	78.6
Corpus Christi	232.0	59.1
Lubbock	174.0	34.7
Arlington	160.1	40.2
Amarillo	149.2	33.0

2000

City	Low		High	
	Population	Acre-Feet	Population	Acre-Feet
	----(thousands)----		----(thousands)----	
Houston	2,055.0	409.7	2,204.3	582.7
Dallas	989.3	212.8	1,032.5	289.1
San Antonio	1,095.3	218.4	1,178.5	311.5
El Paso	684.4	147.2	746.6	160.6
Fort Worth	471.4	87.1	489.0	122.1
Austin	534.5	113.2	594.8	164.6
Corpus Christi	289.4	57.1	299.8	78.6
Lubbock	227.5	44.3	239.7	62.3
Arlington	196.0	37.3	203.3	51.9
Amarillo	167.7	38.0	179.3	52.2

2030

City	Low		High	
	Population	Acre-Feet	Population	Acre-Feet
	----(thousands)----		----(thousands)----	
Houston	2,979.7	594.1	3,576.3	945.4
Dallas	1,312.0	282.2	1,465.9	410.5
San Antonio	1,690.6	337.1	2,174.7	574.9
El Paso	1,081.7	232.6	1,302.3	280.1
Fort Worth	568.7	105.1	626.1	156.4
Austin	774.8	164.0	1,047.0	289.7
Corpus Christi	419.7	82.7	513.0	134.5
Lubbock	299.6	58.4	349.1	90.7
Arlington	236.5	45.0	260.3	66.5
Amarillo	213.3	48.3	249.3	72.6

SOURCE: Texas Department of Water Resources.

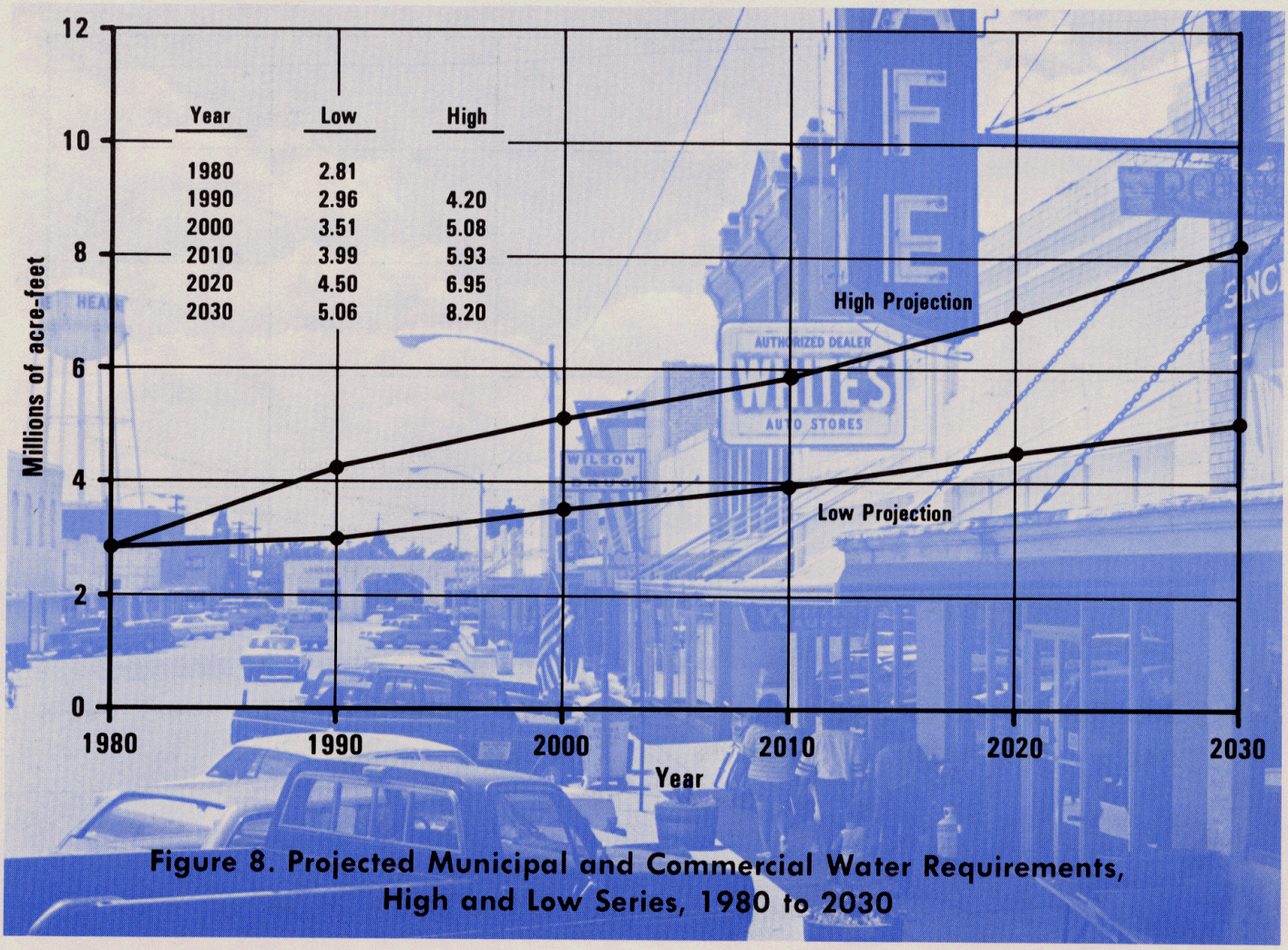

Figure 8. Projected Municipal and Commercial Water Requirements, High and Low Series, 1980 to 2030

Manufacturing industries in the State used 1.5 million acre-feet of water during 1980. Major industries using significant quantities of water include food and beverage products, paper and allied products, chemicals, petroleum refining, and primary metals.

The projections of future industrial water requirements are based upon the growth outlook developed for each of the major industries and upon estimated rates of implementation of industrial water conservation techniques. Manufacturing water requirements in the State are projected to increase by the year 1990 to 2.1 million acre-feet annually, High Series (Figure 9). By 2000, manufacturing water requirements are projected to be 2.7 million acre-feet annually, increasing to 5.0 million acre-feet annually by 2030. The Low Series industrial water requirements are projected to be 2.0 million acre-feet in 1990, 2.4 million acre-feet annually by the year 2000, and 4.2 million acre-feet annually by the year 2030.

In 1980, there existed 50.7 thousand megawatts of steam-electric power generating capacity in the State. Water consumption for power generation totaled 330.0 thousand acre-feet.

Water requirements for steam-electric power generation are based upon projections of future electric power demand, the energy source used for generation, and the specific location of generating capacity. Because of the large, near-surface lignite reserves and the availability of water supplies in the northeastern part of the State, steam-electric power generating capacity is projected to grow significantly in that area. By the year 2000, High Series water requirements for power generation are projected to be 816.9 thousand acre-feet annually (Figure 10). Water requirements for steam-electric power generation in the State are projected to increase to 1.4 million acre-feet annually in 2030. The Low Series water requirements for steam-electric power generation are projected to be 535.3